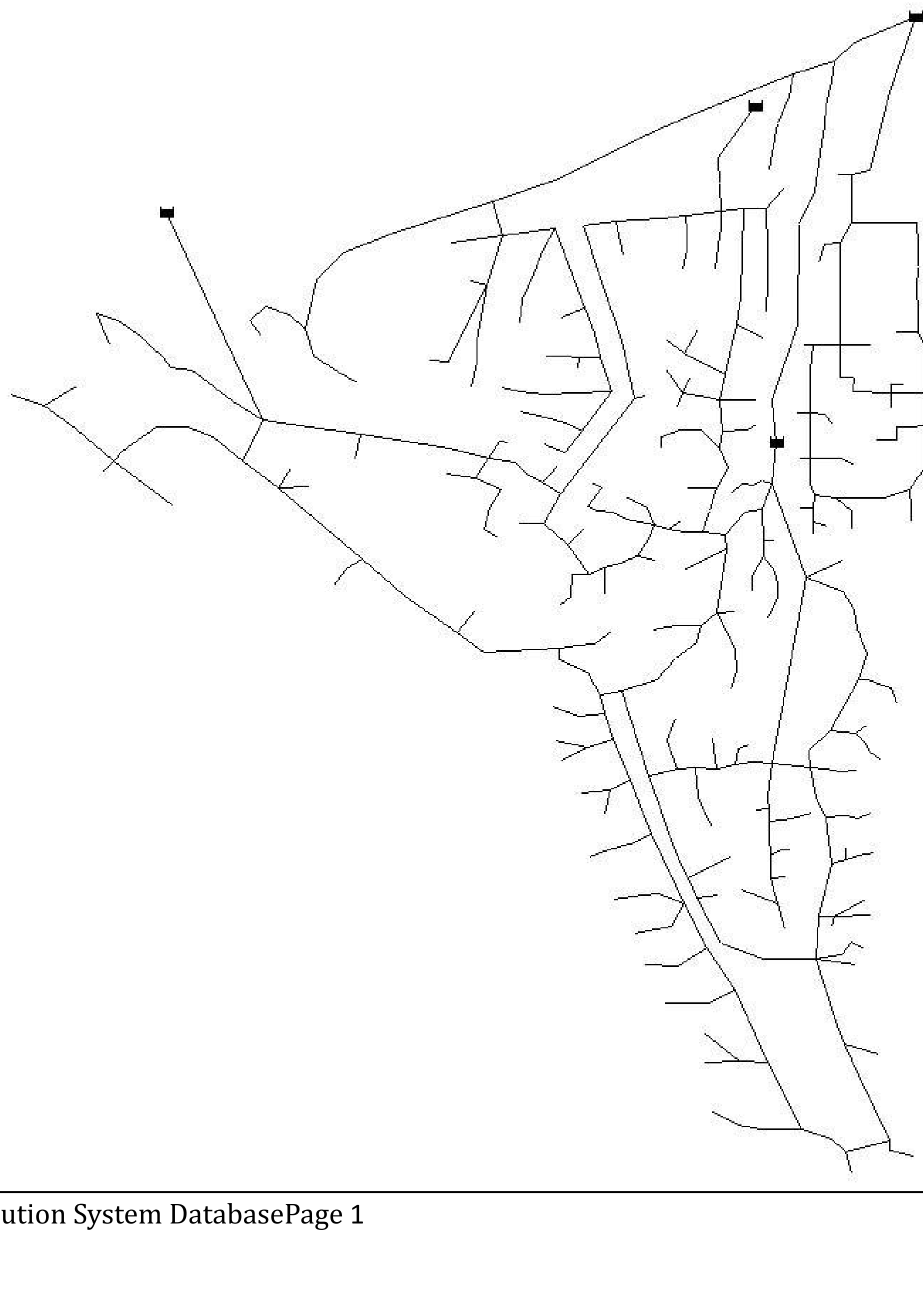
SYSTEM ID: Balerma

NARRATIVE DESCRIPTION

The Balerma system is based on the Sol-Poniente irrigation district. The system has an average demand of 115,000 CMD. The network was first presented by Reca & Martinez (2006) as part of an optimization study. A general schematic of the system is shown below. The system has four reservoirs and 100 kilometers of pipe.

NETWORK SCHEMATIC:



HISTORY OF THE NETWORK FILE

The Balerma system was originally developed by Reca & Martinez (2006) using a genetic algorithm. Since then, it was optimized in various studies using simulated annealing (Reca et al., 2008), particle swarm harmony search (Geem, 2009), memetic algorithm (Banos et al., 2010), nonlinear programming and differential evolution (Zheng et al., 2011), and by incorporating domain knowledge into a generic algorithm model (Bi et al., 2015).

ORIGINAL REFERENCE:

Reca, J. and Martínez, J., 2006. Genetic algorithms for the design of looped irrigation water distribution networks. *Water resources research*, *42*(5). https://doi.org/10.1029/2005WR004383

ABSTRACT: A new computer model called Genetic Algorithm Pipe Network Optimization Model (GENOME) has been developed with the aim of optimizing the design of new looped irrigation water distribution networks. The model is based on a genetic algorithm method, although relevant modifications and improvements have been implemented to adapt the model to this specific problem. It makes use of the robust network solver EPANET. The model has been tested and validated by applying it to the least cost optimization of several benchmark networks reported in the literature. The results obtained with GENOME have been compared with those found in previous works, obtaining the same results as the best published in the literature to date. Once the model was validated, the optimization of a real complex irrigation network was carried out to evaluate the potential of the genetic algorithm for the optimal design of large-scale networks. Although satisfactory results have been obtained, some adjustments would be desirable to improve the performance of genetic algorithms when the complexity of the network requires it.

ADDITIONAL REFERENCES:

Banos, R., Gil, C., Reca, J. and Montoya, F.G. (2010) A memetic algorithm applied to the design of water distribution networks. Applied Soft Computing, 10, 261-266.

Bi, W., Dandy, G. C. and Maier, H. R. (2015) Improved genetic algorithm optimization of water distribution system design by incorporating domain knowledge, Environmental Modelling & Software, Vol. 69, 370-381.

Geem, Z.W. (2009) Particle-swarm harmony search for water network design. Engineering Optimization 41 (4), 297-311.

Reca, J., Martinez, J., Gil, C., and Banos, R. (2008) Application of several meta-heuristic techniques to the optimization of real looped water distribution systems, Water Resour. Man., 22, 1367-1379.

Zheng, F., Simpson, A.R., and Zecchin, A.C. (2011) A combined NLP-differential evolution algorithm approach for the optimization of looped water distribution systems, Water Resour. Res., 47, W08531.

ADDITIONAL CITATIONS:

The original publication of Reca & Martinez (2006) and by inference the Balerma system have been cited by 235 additional authors. These may be accessed by moving your cursor over the following link while simultaneously depressing the CTRL key on your keyboard: [235 Citations.]

AVAILABLE INFORMATION

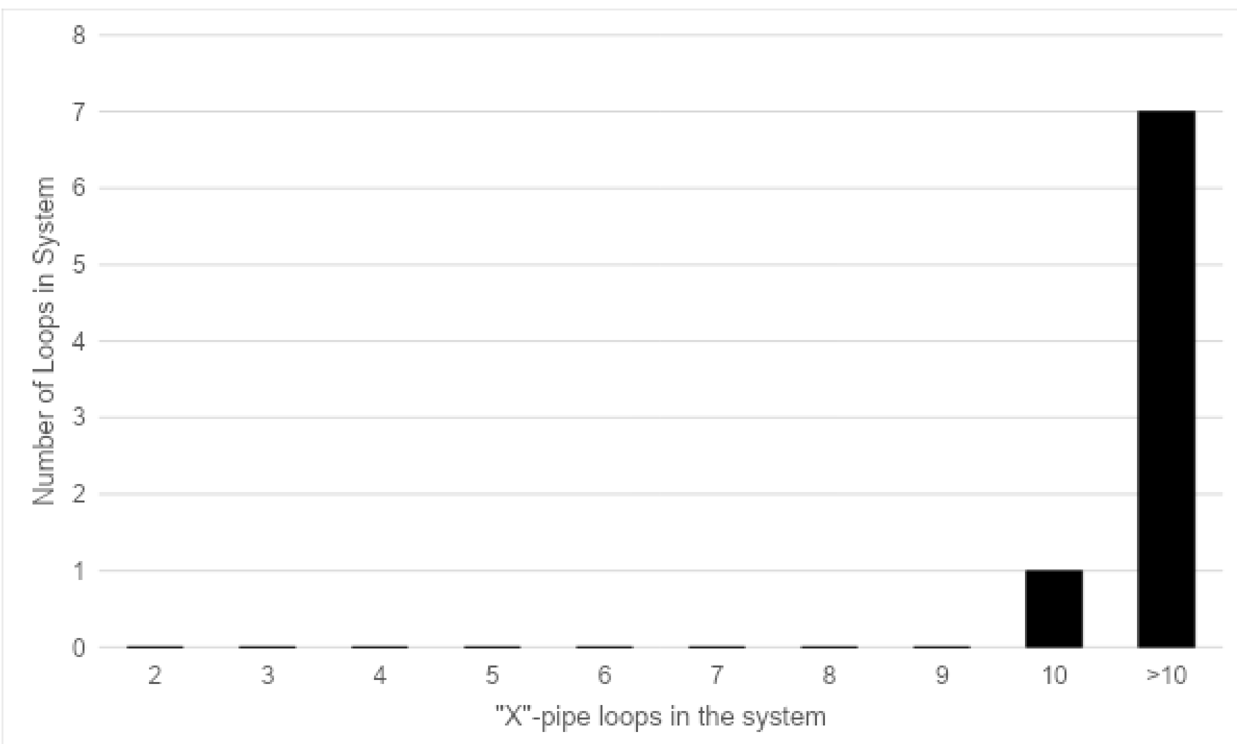
Physical attributes	Yes
Schematic diagram	Yes
Network geometry data	Yes
GIS data file	No
Background map	No
Elevation data	Yes
Pipe data	Yes
Pipe material	No
Pipe age	No
Pipe pressure class	No
Nominal or actual diameters	Actual
Pump data	NA
Useful horsepower	
Pump operating curves	
Tank data	NA
Elevation data	
Stage storage curves	
Water quality information	
Valve data	NA
PRV/FCV data	
Isolation valve data	
Hydrant data	
Demand data	Yes
Total system demand	No
Nodal demand data	Yes
Temporal data demands	No
System leakage	No
Hydraulic data	No
Hydraulically calibrated model	
Field hydraulic calibration data	
Water quality data	No
Disinfection method	
Chlorine residual data	
Booster station data	
Fluoride/Chloride field data	
Water quality calibrated model	
Operational data	No
SCADA datasets	
Operational rules	

SYSTEM CLASSIFICATION:

PIPE/LOOP HISTOGRAM:

Hoagland et al. (2015) designed a network classification algorithm for use in classifying water distribution systems as either “branched,” “looped,” or “gridded” based on the observed frequency of network loops with different numbers of distinct pipe segments. The frequency distribution for the Balerma system is provided below. Using this information, Hoagland et al., classified this system as being a BRANCHED system.

# Total Pipes:	454
# Branch Pipes:	308
Ratio (Branch Pipes / Total Pipes):	0.678



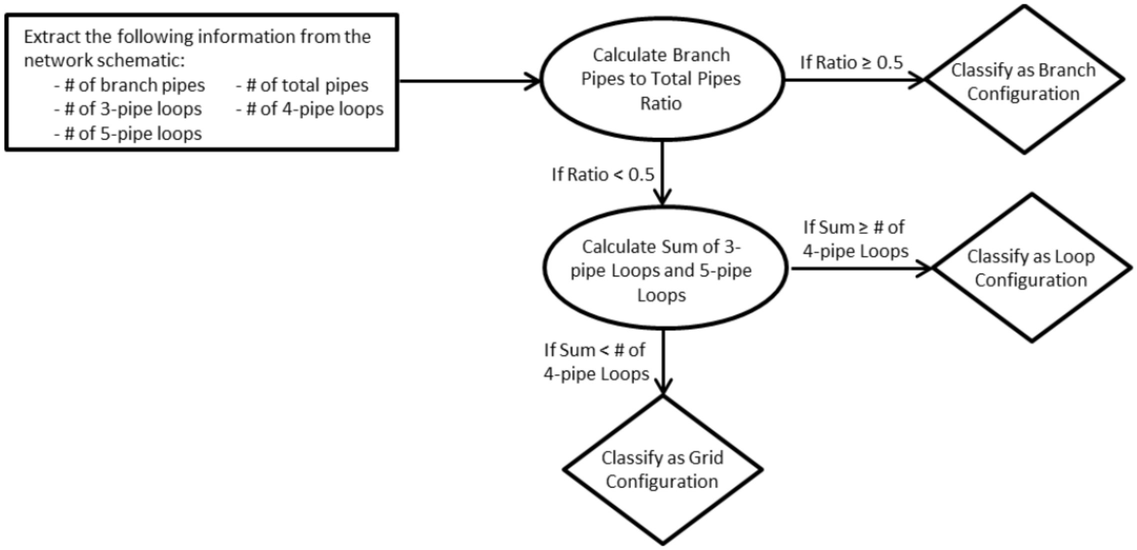


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

Hoagland, Steven & Schal, Stacey & Ormsbee, Lindell & Bryson, Lindsey. (2015). Classification of Water Distribution Systems for Research Applications. 696-702. 10.1061/9780784479162.064.

NETWORK STRUCTURE METRICS:

Building on the work of Hoagland et al., (2015), Hwang & Lansey (2017) created an expanded classification system that allows for further classification of a system as being either a transmission or distribution branched, looped, gridded, or hybrid system. Their algorithm streamlines the classification system by removing unnecessary nodes that do not contribute to the structure of the system while still retaining their use as intermediate points for demand data entry. A full description of the algorithm can be found in the cited reference.

Application of the Hwang and Lansey classification algorithm to the system yields the following statics and associated classification:

Parameter	Value
Edges	454
Pipes	454
Nodes	447
Average Diameter	164
Reduced Nodes	80
Reduced Edges	87
Branched Edges	292
Branched Index	0.8
Meshed Connectedness	0
Reduced Meshed Connectedness	0.05
Link Density	0
Average Node Degree	2
Hwang & Lansey Classification	Distribution Branch

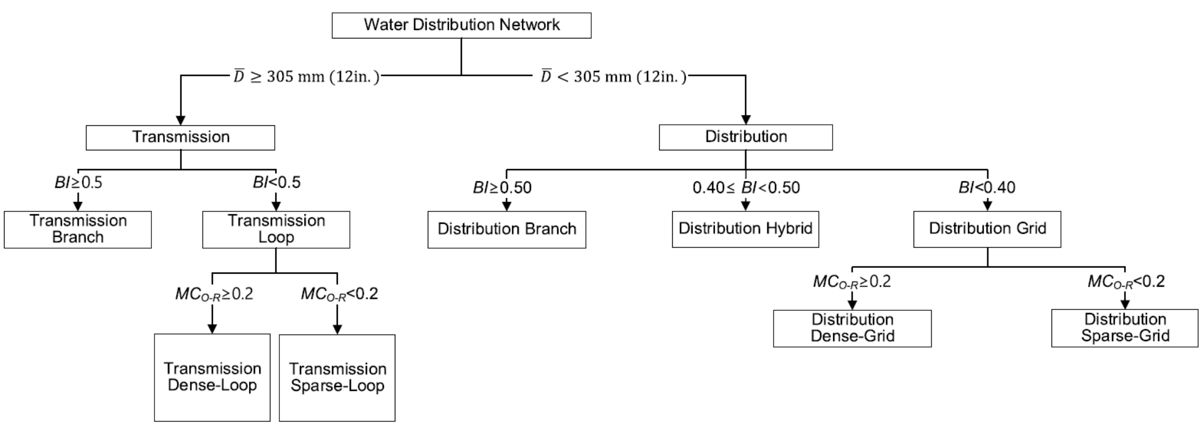


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)

Hwang H. & Lansey, K. (2015) “Water distribution system classification using system characteristics and graph theory metrics.” *Journal of water resource planning and management* 143(12) https://doi.org/10.1061/(ASCE)WR.1943-5452.0000850

DETAILED DATA SUMMARIES

PHYSICAL ASSETS:

Asset Type:	# of Assets
Master Meters	0
Tanks	0
Pumps	0
Water Sources	4

NETWORK CHARACTERISTICS:

# Total Pipes:	454
# Junctions	443
# Reservoirs	4
# Tanks	0
# Regulating Valves	0
# Isolation Values	0
# Hydrants	Unknown
Elevation Data	YES

PIPE DATA:

Diameter (mm)	Length (m)
113	58,586
126.6	4,657
144.6	5,318
162.8	4,877
180.8	3,156
226.2	4,941
285	10,77
361.8	7,404
452.2	554

PUMP DATA:

Pump Horsepower	NO
Pump Curves:	NO

DATA FILE ATTRIBUTES:

ATTRIBUTE		UNITS
Pipe Length & Diameter	X	Meters and Millimeters
Pipe Age		
Node Elevation	X	Meters
Node Demand	X	LPS
Valves		
Hydrants		
Tank Levels		
Tank Volume		
PRVs		
WTP		
WTP Capacity		
Pump Data		